

# CTR

# LCD Color Characteristics

2012/06/25

Version 1.0

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# 1 Introduction

This document explains the color characteristics of the CTR (Nintendo 3DS) and SPR (Nintendo 3DS XL) built-in LCD screens. Refer to this document if you notice any problems in color differences between the PC monitor and the CTR LCD screens, such as when creating graphical elements.

**Note:** The CTR and SPR LCDs are the same except for their size. Unless there are notes to the contrary, anything written about the characteristics of the CTR LCD applies as is to the SPR LCD as well.

## 1.1 Structure of This Document

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This document consists of the following chapters.

- Introduction

This chapter provides an overview of the document and basic information about the LCD screens.

- LCD Screen Characteristics

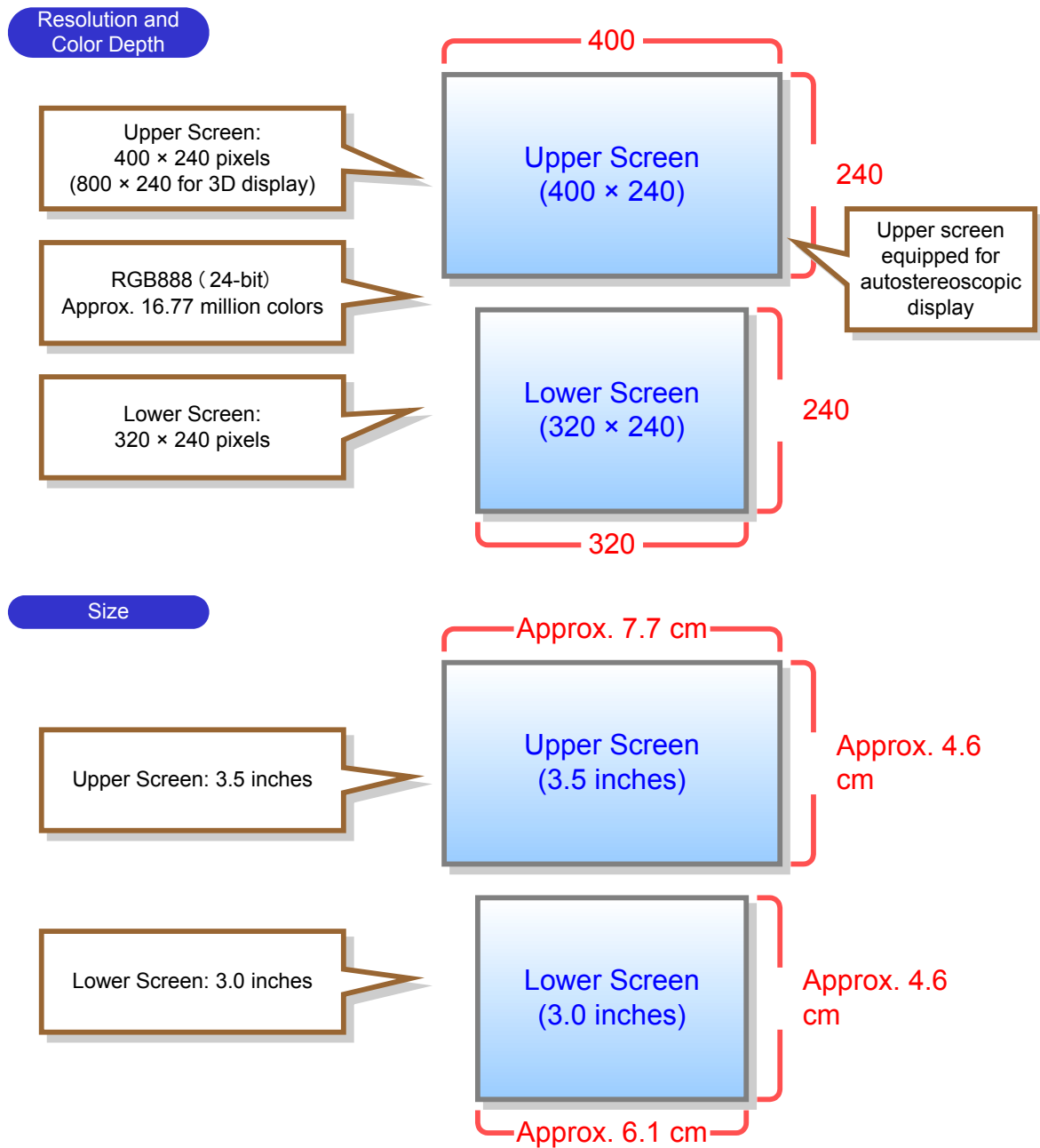
This chapter provides more detailed information about the CTR system's LCD screen characteristics and describes a conversion method for displaying on a PC monitor using colors similar to those on the CTR LCD screens.

## 1.2 Basic Specifications

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The CTR system comes with two LCD screens: the upper screen and the lower screen. The upper screen can be used for autostereoscopic display. The basic specifications of the LCD screens are as follows.

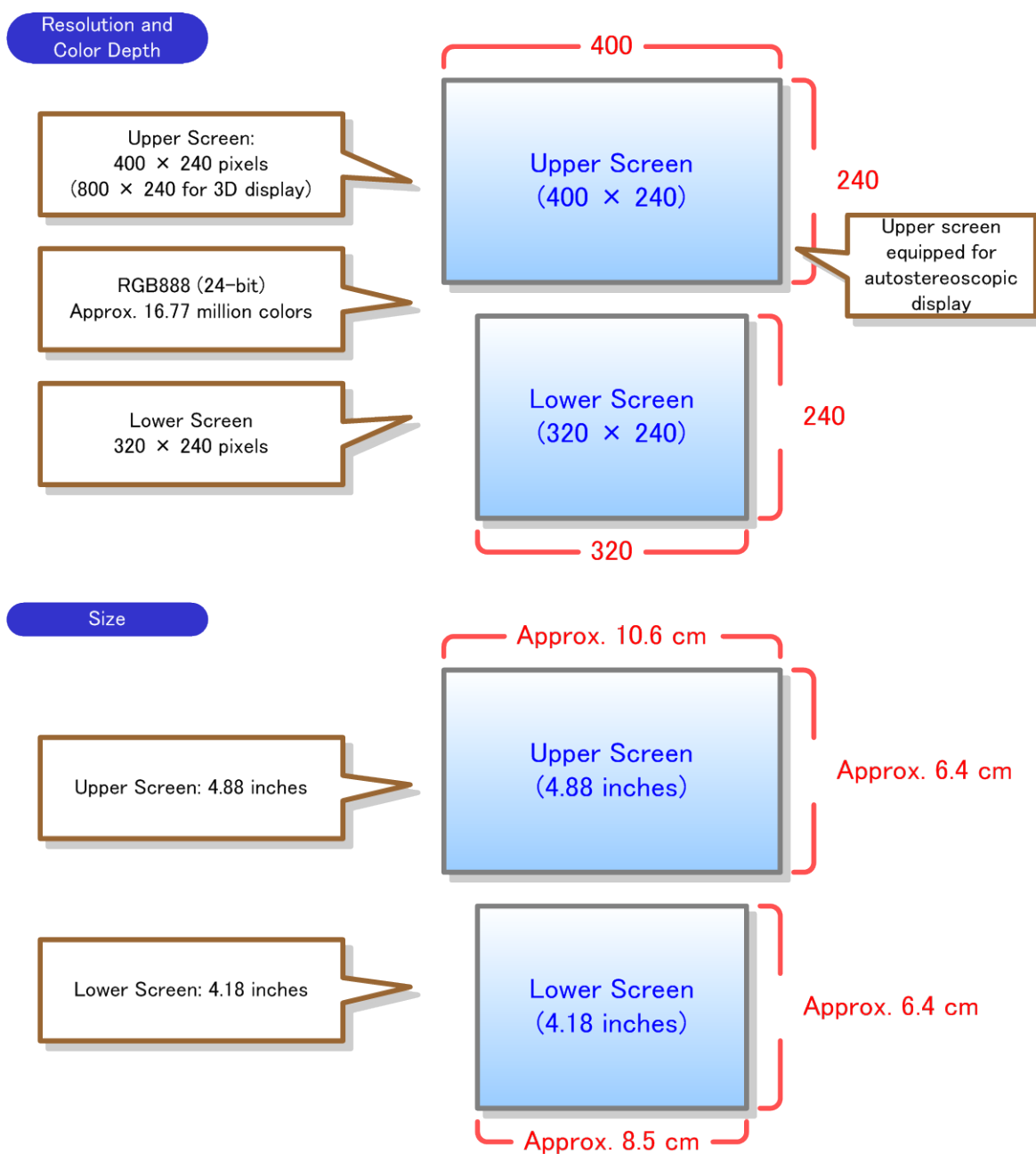
**Figure 1-1 Basic Specifications (CTR)**



**Note:** Colors may change on the upper screen when 3D display is enabled due to changes in the parallax barrier and the backlight. The data in this document assumes that 3D display is not enabled.

The SPR system is essentially the same as the CTR system, but the size of the LCD screens differs.

**Figure 1-2 Basic Specifications (SPR)**



## 1.3 System Settings

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The system settings include the following items that users can change for the LCD screens.

**Table 1-1 Display Settings**

| Setting            | Description                                                                                                                                                                                                                                                                |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Energy-saving mode | Energy-saving feature to automatically adjust the brightness of the backlight in response to the images displayed. The default setting is Off.                                                                                                                             |
| Brightness         | Changes the brightness of the display from 1 to 5. The default setting is 5. With CTR, when set to 4 or 5, the screen becomes even brighter when the AC adapter is plugged in. With SPR, the brightness does not change depending on whether the AC adapter is plugged in. |

**Note:** When using the energy-saving mode, the screen may flicker and colors may change depending on the image displayed.

## 2 LCD Screen Characteristics

This chapter describes the CTR LCD screen characteristics. Unless otherwise noted, the data in this chapter assumes that the energy-saving mode is off, the brightness is set to 5, and the AC adapter is plugged in. The data presents the standard values for the CTR system. Note that each individual system may be slightly different.

### 2.1 White Characteristics

The following values are the standard for the CTR LCD screens when displaying white (a color value of 255, 255, 255). These are the standard values for comparing with a regular PC monitor.

**Table 2-1 White Characteristics**

| Item              | Value                 |
|-------------------|-----------------------|
| Brightness        | 190 cd/m <sup>2</sup> |
| Color temperature | 6644 K                |
| CIExy             | (x, y) = (0.31, 0.33) |

**Note:** You must first adjust your PC monitor to approximate the above values before adjusting colors to make the PC monitor display approach that of the CTR LCD display, as described in section 2.2.2 Color Conversion.

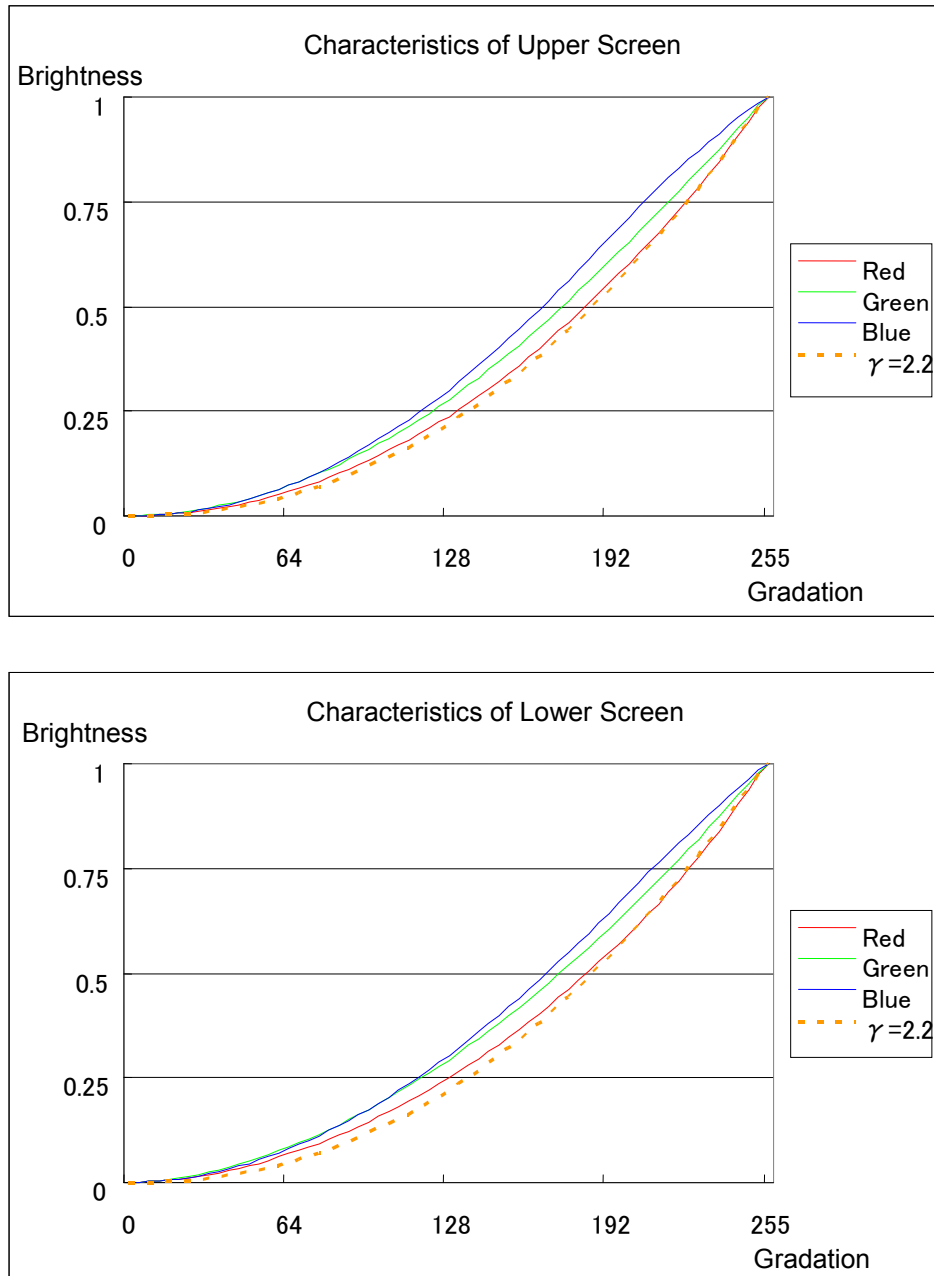
### 2.2 Gamma Value

The publicly released gamma value for the CTR system's gray gamma is 2.0 (the gamma value when all three RGB component values are the same). This produces a higher brightness for the middle range than for a regular PC monitor, which has a gray gamma value of 2.2. The characteristics also differ by RGB component, leading to apparent differences in color.

#### 2.2.1 Color Component Characteristics

The following figure shows the characteristics of each color component on the CTR system's LCD screens.



**Figure 2-1 Color Component Characteristics**

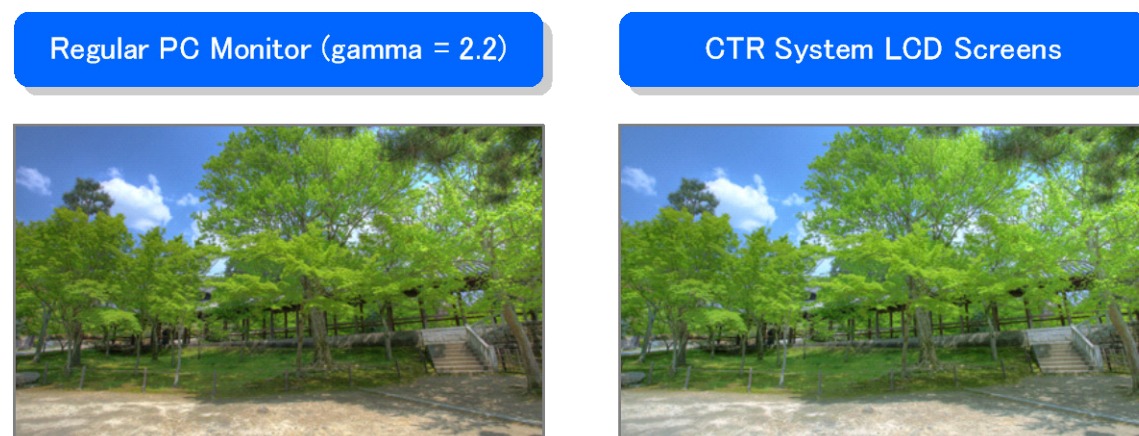
Each color component has the following characteristics compared to a regular PC monitor, which has a gamma value of 2.2.

**Table 2-2 Color Component Characteristics**

| Color | Description                                                                                                                                                                                                                                |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Red   | For high brightness values, this is roughly equivalent to a gamma of 2.2, but for low to medium brightness values, the brightness is higher than for a PC monitor, with a gamma value approaching 2.0.                                     |
| Green | Curve approaching a gamma of 1.8 for low through high brightness values.                                                                                                                                                                   |
| Blue  | Curve even lower than a gamma of 1.8. Curve is close to a gamma of 1.8 for low brightness values, but for medium to high brightness values, the curve trends substantially higher. This propensity is more pronounced on the upper screen. |

In aggregate, this leads to colors in the intermediate range appearing more brightly on CTR than on a regular PC monitor, with greens and blues stronger for low to medium brightness values, and even stronger blues at high brightness values. See section 2.2.3 Gradation and Brightness Details for detailed numbers.

Displaying the same image on a regular PC monitor and the CTR LCD screens will result in the following kind of difference.

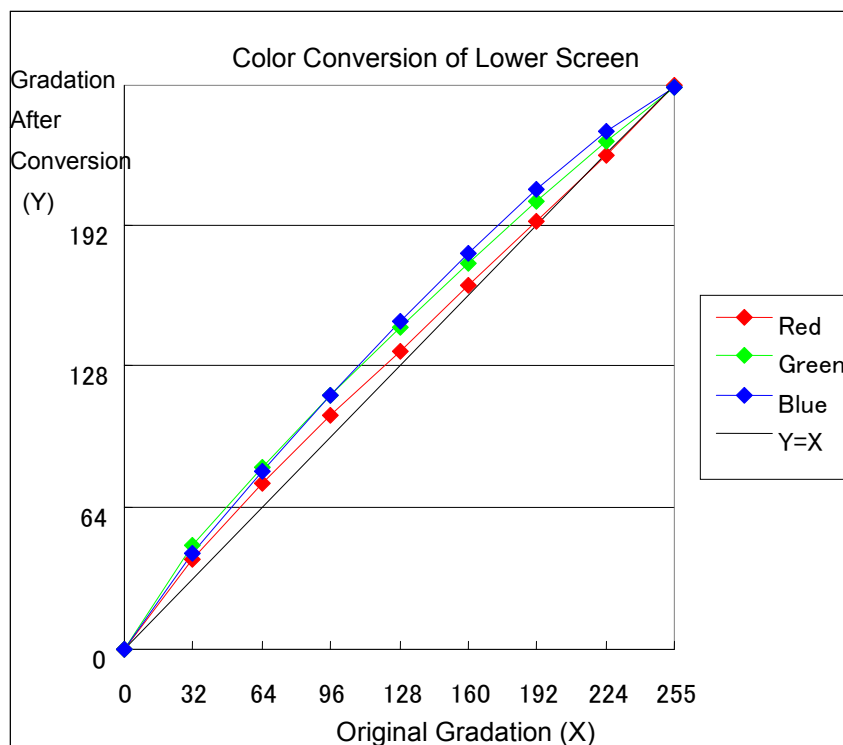
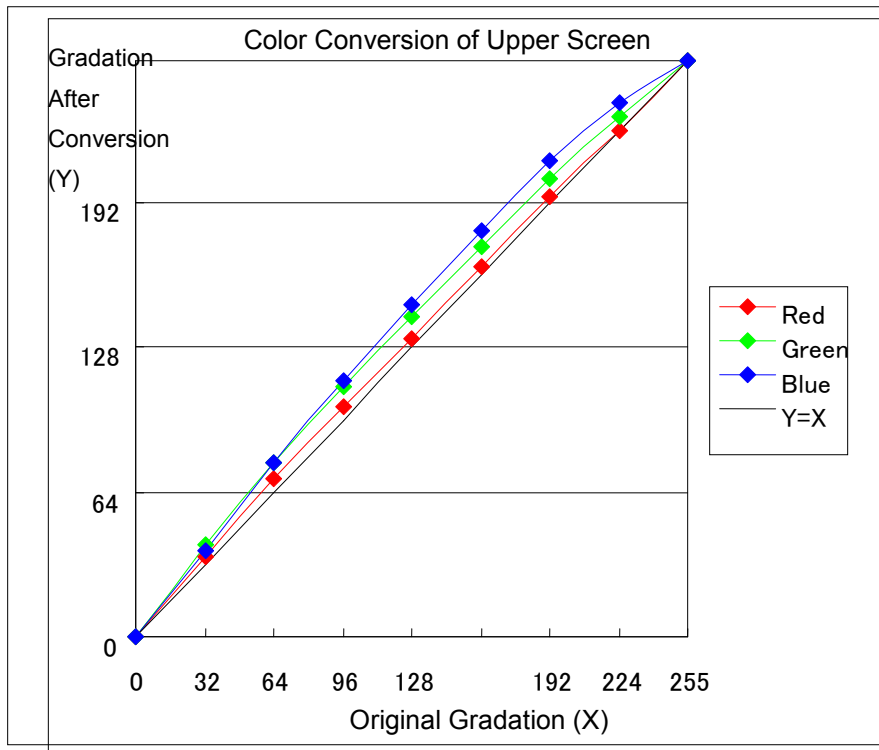
**Figure 2-2 Comparing Displays on the CTR LCD Screen and a Regular PC Monitor**

**Note:** The figure above is for illustration only. Your own image display may differ due to monitor settings and individual CTR system differences. Check the colors on the actual hardware.

## 2.2.2 Color Conversion

The following curve shows a graph of converting the RGB color components displayed on a regular PC monitor (gamma of 2.2) for display on the CTR LCD screens. Adjust the values for each color component using this curve to derive values closer to those displayed on the CTR screens.

**Figure 2-3 Color Conversion**



The actual conversion equation is as follows. When displaying on a regular PC monitor, apply the conversion to the original image to obtain color values close to those when displaying the original image on the CTR LCD screens.

**Table 2-3 Color Conversion**

| LCD Screen   | Color | Formula                                                                                                                                                                          |
|--------------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upper screen | R     | $y = 0.0000000000483248154 x^6 - 0.00000000365657475197 x^5 + 0.00000102757545328291 x^4 - 0.00012874649109306800 x^3 + 0.00614448620945041000 x^2 + 1.01590738243613000000 x$   |
|              | G     | $y = 0.00000000000329555011 x^6 - 0.00000000244753003129 x^5 + 0.00000065405100738158 x^4 - 0.00007222040740728630 x^3 + 0.00144633215450085000 x^2 + 1.27791283459010000000 x$  |
|              | B     | $y = 0.00000000000491878788 x^6 - 0.00000000394859958012 x^5 + 0.00000117626844803320 x^4 - 0.00016190261042226000 x^3 + 0.00939849207111365000 x^2 + 1.02038300762433000000 x$  |
| Lower screen | R     | $y = 0.00000000000055564880 x^6 - 0.00000000020347151438 x^5 - 0.00000003641248849662 x^4 + 0.00003010197559660810 x^3 - 0.00605157260929445000 x^2 + 1.44932875573431000000 x$  |
|              | G     | $y = -0.00000000000204162633 x^6 + 0.00000000185329685550 x^5 - 0.00000067395978842200 x^4 + 0.00012607237891515400 x^3 - 0.01352555023322570000 x^2 + 1.78866456432661000000 x$ |
|              | B     | $y = -0.00000000000100175749 x^6 + 0.00000000083670822560 x^5 - 0.00000029910139492939 x^4 + 0.00005678244610152210 x^3 - 0.00673510040201108000 x^2 + 1.52480247021595000000 x$ |

**Note:** X here is the input image data with 8 bits for each RGB component representing gradations between 0 and 255. Y here is the converted image data with 8 bits for each RGB component.

## 2.2.3 Gradation and Brightness Details

This table shows detailed gradation and brightness data for the CTR LCD screens.

**Table 2-4 Gradation and Brightness Details (Upper Screen)**

| Gradation | Brightness |       |       |       | Gradation | Brightness |       |       |       |
|-----------|------------|-------|-------|-------|-----------|------------|-------|-------|-------|
|           | Gray       | Red   | Green | Blue  |           | Gray       | Red   | Green | Blue  |
| 0         | 0.000      | 0.000 | 0.000 | 0.000 | 132       | 0.268      | 0.254 | 0.294 | 0.320 |
| 4         | 0.000      | 0.000 | 0.000 | 0.000 | 136       | 0.284      | 0.270 | 0.312 | 0.340 |
| 8         | 0.001      | 0.001 | 0.002 | 0.001 | 140       | 0.301      | 0.287 | 0.330 | 0.360 |
| 12        | 0.002      | 0.002 | 0.003 | 0.002 | 144       | 0.319      | 0.304 | 0.349 | 0.381 |

| Gradation | Brightness |       |       |       | Gradation | Brightness |       |       |       |
|-----------|------------|-------|-------|-------|-----------|------------|-------|-------|-------|
|           | Gray       | Red   | Green | Blue  |           | Gray       | Red   | Green | Blue  |
| 16        | 0.004      | 0.003 | 0.005 | 0.004 | 148       | 0.337      | 0.322 | 0.368 | 0.402 |
| 20        | 0.006      | 0.006 | 0.008 | 0.006 | 152       | 0.355      | 0.340 | 0.387 | 0.424 |
| 24        | 0.009      | 0.008 | 0.011 | 0.009 | 156       | 0.374      | 0.359 | 0.407 | 0.446 |
| 28        | 0.012      | 0.011 | 0.015 | 0.013 | 160       | 0.394      | 0.379 | 0.428 | 0.468 |
| 32        | 0.016      | 0.014 | 0.019 | 0.017 | 164       | 0.414      | 0.399 | 0.449 | 0.491 |
| 36        | 0.020      | 0.018 | 0.024 | 0.022 | 168       | 0.434      | 0.419 | 0.470 | 0.514 |
| 40        | 0.025      | 0.023 | 0.029 | 0.027 | 172       | 0.455      | 0.441 | 0.492 | 0.538 |
| 44        | 0.030      | 0.027 | 0.035 | 0.033 | 176       | 0.476      | 0.463 | 0.514 | 0.562 |
| 48        | 0.035      | 0.033 | 0.041 | 0.040 | 180       | 0.498      | 0.485 | 0.537 | 0.587 |
| 52        | 0.042      | 0.038 | 0.048 | 0.047 | 184       | 0.521      | 0.508 | 0.560 | 0.612 |
| 56        | 0.048      | 0.044 | 0.056 | 0.055 | 188       | 0.544      | 0.532 | 0.584 | 0.637 |
| 60        | 0.055      | 0.051 | 0.064 | 0.063 | 192       | 0.567      | 0.556 | 0.608 | 0.663 |
| 64        | 0.063      | 0.058 | 0.072 | 0.072 | 196       | 0.591      | 0.578 | 0.631 | 0.688 |
| 68        | 0.071      | 0.066 | 0.082 | 0.082 | 200       | 0.615      | 0.602 | 0.654 | 0.713 |
| 72        | 0.080      | 0.074 | 0.091 | 0.093 | 204       | 0.640      | 0.626 | 0.678 | 0.738 |
| 76        | 0.089      | 0.083 | 0.102 | 0.104 | 208       | 0.665      | 0.650 | 0.702 | 0.761 |
| 80        | 0.098      | 0.092 | 0.112 | 0.116 | 212       | 0.691      | 0.676 | 0.726 | 0.785 |
| 84        | 0.109      | 0.102 | 0.123 | 0.128 | 216       | 0.718      | 0.702 | 0.750 | 0.807 |
| 88        | 0.119      | 0.112 | 0.135 | 0.141 | 220       | 0.744      | 0.730 | 0.775 | 0.829 |
| 92        | 0.130      | 0.122 | 0.147 | 0.154 | 224       | 0.772      | 0.758 | 0.799 | 0.851 |
| 96        | 0.142      | 0.133 | 0.160 | 0.168 | 228       | 0.799      | 0.786 | 0.825 | 0.872 |
| 100       | 0.154      | 0.145 | 0.173 | 0.183 | 232       | 0.828      | 0.816 | 0.850 | 0.893 |
| 104       | 0.166      | 0.157 | 0.186 | 0.198 | 236       | 0.857      | 0.846 | 0.875 | 0.913 |
| 108       | 0.179      | 0.169 | 0.200 | 0.213 | 240       | 0.886      | 0.877 | 0.901 | 0.932 |
| 112       | 0.193      | 0.182 | 0.215 | 0.230 | 244       | 0.916      | 0.909 | 0.927 | 0.951 |
| 116       | 0.207      | 0.196 | 0.230 | 0.246 | 248       | 0.946      | 0.941 | 0.953 | 0.969 |
| 120       | 0.222      | 0.209 | 0.245 | 0.264 | 252       | 0.977      | 0.975 | 0.980 | 0.987 |

| Gradation | Brightness |       |       |       | Gradation | Brightness |       |       |       |
|-----------|------------|-------|-------|-------|-----------|------------|-------|-------|-------|
|           | Gray       | Red   | Green | Blue  |           | Gray       | Red   | Green | Blue  |
| 124       | 0.236      | 0.224 | 0.261 | 0.282 | 255       | 1.000      | 1.000 | 1.000 | 1.000 |
| 128       | 0.252      | 0.238 | 0.277 | 0.300 |           |            |       |       |       |

**Table 2-5 Gradation and Brightness Details (Lower Screen)**

| Gradation | Brightness |       |       |       | Gradation | Brightness |       |       |       |
|-----------|------------|-------|-------|-------|-----------|------------|-------|-------|-------|
|           | Gray       | Red   | Green | Blue  |           | Gray       | Red   | Green | Blue  |
| 0         | 0.000      | 0.000 | 0.000 | 0.000 | 132       | 0.268      | 0.265 | 0.310 | 0.322 |
| 4         | 0.000      | 0.001 | 0.001 | 0.000 | 136       | 0.284      | 0.280 | 0.327 | 0.341 |
| 8         | 0.001      | 0.002 | 0.003 | 0.002 | 140       | 0.301      | 0.296 | 0.344 | 0.360 |
| 12        | 0.002      | 0.003 | 0.005 | 0.003 | 144       | 0.319      | 0.312 | 0.362 | 0.379 |
| 16        | 0.004      | 0.006 | 0.008 | 0.006 | 148       | 0.337      | 0.329 | 0.380 | 0.399 |
| 20        | 0.006      | 0.008 | 0.011 | 0.009 | 152       | 0.355      | 0.346 | 0.399 | 0.419 |
| 24        | 0.009      | 0.011 | 0.015 | 0.012 | 156       | 0.374      | 0.364 | 0.418 | 0.440 |
| 28        | 0.012      | 0.015 | 0.019 | 0.016 | 160       | 0.394      | 0.383 | 0.437 | 0.461 |
| 32        | 0.016      | 0.019 | 0.024 | 0.021 | 164       | 0.414      | 0.402 | 0.457 | 0.482 |
| 36        | 0.020      | 0.023 | 0.030 | 0.026 | 168       | 0.434      | 0.421 | 0.477 | 0.504 |
| 40        | 0.025      | 0.028 | 0.036 | 0.032 | 172       | 0.455      | 0.441 | 0.498 | 0.526 |
| 44        | 0.030      | 0.034 | 0.043 | 0.039 | 176       | 0.476      | 0.461 | 0.519 | 0.549 |
| 48        | 0.035      | 0.040 | 0.050 | 0.046 | 180       | 0.498      | 0.482 | 0.540 | 0.572 |
| 52        | 0.042      | 0.046 | 0.058 | 0.054 | 184       | 0.521      | 0.504 | 0.562 | 0.595 |
| 56        | 0.048      | 0.053 | 0.067 | 0.062 | 188       | 0.544      | 0.526 | 0.584 | 0.619 |
| 60        | 0.055      | 0.061 | 0.076 | 0.071 | 192       | 0.567      | 0.548 | 0.607 | 0.643 |
| 64        | 0.063      | 0.069 | 0.085 | 0.081 | 196       | 0.591      | 0.570 | 0.629 | 0.668 |
| 68        | 0.071      | 0.077 | 0.095 | 0.091 | 200       | 0.615      | 0.593 | 0.652 | 0.692 |
| 72        | 0.080      | 0.085 | 0.105 | 0.101 | 204       | 0.640      | 0.616 | 0.675 | 0.716 |
| 76        | 0.089      | 0.094 | 0.115 | 0.112 | 208       | 0.665      | 0.641 | 0.699 | 0.740 |
| 80        | 0.098      | 0.103 | 0.126 | 0.124 | 212       | 0.691      | 0.666 | 0.723 | 0.763 |

| Gradation | Brightness |       |       |       | Gradation | Brightness |       |       |       |
|-----------|------------|-------|-------|-------|-----------|------------|-------|-------|-------|
|           | Gray       | Red   | Green | Blue  |           | Gray       | Red   | Green | Blue  |
| 84        | 0.109      | 0.113 | 0.138 | 0.136 | 216       | 0.718      | 0.693 | 0.747 | 0.787 |
| 88        | 0.119      | 0.123 | 0.150 | 0.148 | 220       | 0.744      | 0.720 | 0.771 | 0.810 |
| 92        | 0.130      | 0.134 | 0.162 | 0.162 | 224       | 0.772      | 0.748 | 0.796 | 0.832 |
| 96        | 0.142      | 0.145 | 0.175 | 0.175 | 228       | 0.799      | 0.778 | 0.821 | 0.855 |
| 100       | 0.154      | 0.157 | 0.188 | 0.190 | 232       | 0.828      | 0.808 | 0.847 | 0.877 |
| 104       | 0.166      | 0.169 | 0.202 | 0.204 | 236       | 0.856      | 0.839 | 0.873 | 0.899 |
| 108       | 0.179      | 0.181 | 0.216 | 0.220 | 240       | 0.886      | 0.871 | 0.899 | 0.921 |
| 112       | 0.193      | 0.194 | 0.231 | 0.235 | 244       | 0.916      | 0.904 | 0.925 | 0.942 |
| 116       | 0.207      | 0.207 | 0.246 | 0.252 | 248       | 0.946      | 0.938 | 0.952 | 0.963 |
| 120       | 0.221      | 0.221 | 0.261 | 0.269 | 252       | 0.977      | 0.973 | 0.979 | 0.984 |
| 124       | 0.236      | 0.236 | 0.277 | 0.286 | 255       | 1.000      | 1.000 | 1.000 | 1.000 |
| 128       | 0.252      | 0.250 | 0.293 | 0.304 |           |            |       |       |       |

## Revision History

| Version | Revision Date | Category | Description                                                                                                                                                                    |
|---------|---------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.0     | 2012/06/25    | Changed  | 1 Introduction<br>Added information about SPR.<br>1.2 Basic Specifications<br>Added information and a figure about SPR.<br>1.3 System Settings<br>Added information about SPR. |
| 0.1     | 2010/11/17    | —        | Initial version.                                                                                                                                                               |



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